22. (New) The flameless distributed combustion process heater of claim 18 wherein said process chamber contains catalyst and the process conducted in said process chamber is the production of styrene by the dehydrogenation of ethyl benzene.

DS end

23. (New) The flameless distributed combustion process heater of claim 18 wherein said process chamber contains catalyst and the process conducted in said process chamber is steam hydrocarbon reforming to convert a hydrocarbon and steam to hydrogen, carbon monoxide and carbon dioxide.

24. (New) The flameless distributed combustion process heater of claim 18 wherein said oxidant is preheated by heat exchange with effluent from said process chamber.

REMARKS

Please charge any additional fees due for the claims added by the above amendments to Deposit Account No. 19-1800, Shell Oil Company.

The above amendments to the existing claims and the added claims are made to better define the claimed invention. Support for each of these amendments and the added claims is discussed in the following paragraphs.

Applicant will now address the points raised in the Examiner's Detailed Action in the same order as they are presented in the Action.

1. The Examiner objects to the Preliminary Amendment filed on 16 November 1998 on the basis it introduces new matter into the disclosure. Applicant respectfully traverses this objection on the basis the equations included in the Amendment were in

ack Marian ok to alter per J. Johnson

fact included, word for word, on pages 8 and 9 of Applicant's provisional application No. 60/062,239, filed October 8, 1997. Since the present application claims the priority of said provisional application, the equations which were inadvertently left out of the present application are not new matter, but part of the original disclosure in the parent provisional application. Therefore, it is respectfully requested that the objection to the Preliminary Amendment filed on 16 November 1998 be withdrawn.

2. The Examiner is thanked for pointing out the duplication of the reference to the parent provisional application. This is believed corrected by the above amendment deleting the duplicate reference.

3. The Examiner is thanked for pointing out the equation given for the shift gas reaction is unclear, and for pointing out the inconsistencies in the numbering of the oxidation/combustion chamber. The above amendments correct the shift gas reaction equation and eliminate the inconsistencies in numbering of the oxidation/combustion chamber. The correction of equation (5) does not introduce new matter, since the correct equation for the shift gas reaction is presented on page 9 of the parent provisional application, the priority of which is claimed in the present application. The correction of the inconsistencies in the numbering of the oxidation/combustion chamber likewise does not introduce new matter since this element is identified by the number "1" in the drawings, and at numerous points in the specification as noted by the Examiner.

4. The Examiner is thanked for pointing out that reference "15" shown in Figure 1, is not described in the specification. The above amendment to the specification describing "15" as being an outlet for the quenched (cooled) process stream exiting the quench heat exchanger is believed to address this objection. The description of "15" as an

outlet for the quenched process stream is clearly supported by the drawing itself, and the rest of the description of Figure 1 on pages 6 and 7 of the specification. Therefore, this amendment does not introduce new matter.

5. In this paragraph the Examiner has objected to claims 2-3 and 16-17 on the basis of certain informalities. Since prior to the addition of the new claims above, there were only 15 claims in the application, the Examiner's reference to "claims 16-17" is obviously in error. The informalities specifically listed by the Examiner in Paragraph 5 all appear to relate to claims 1 and 2. Each of the specifically listed informalities has either been corrected by adopting the language suggested by the Examiner, or rendered moot by the above amendments to claims 1 and 2, which delete the objected to language.

6. and 7. In these paragraphs the examiner rejects claims 1-7 and 13-15 under 35 U.S.C. 112, second paragraph, as being indefinite or failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In the following paragraphs, Applicant will attempt to respond each of the specific comments made by the Examiner.

However, before addressing the specific points raised by the Examiner, Applicant believes it might be helpful to briefly review the basic elements of the claimed process heater and how these elements interact. This may assist in clarifying some of the claim language which the Examiner finds unclear.

The process heater of the present invention comprises three basic elements: (1) an oxidation chamber containing a fuel conduit with a plurality of nozzles distributed along the length of the oxidation chamber (this provides "distributed" combustion), said nozzles being spaced to produce combustion without a flame (this provides "flameless"

combustion), when fuel is mixed with an oxidant in the oxidation chamber, (2) a preheater for heating the oxidant to a temperature that when the oxidant and fuel are mixed in the oxidation chamber, the temperature of the resulting mixture will exceed the autoignition temperature of the mixture, and (3) a process chamber in which various endothermic chemical reactions (or distillation or reboiling) are conducted, often in the presence of a catalyst.

The necessary high heat flux for these reactions is provided to the process chamber by the oxidation chamber in a controlled manner, with significant benefits over conventional means of heating these reactions. The resulting benefits, to name a few, include improved conversions, improved selectivities and/or yields, reduced byproduct formation, extremely low NO_x levels, and reduced metallurgical constraints in the equipment used because of the absence of high temperature flames. These benefits are achieved as a result of the combination of "flameless" and "distributed" combustion, both of which concepts are key to the present invention. The newly added claims 18-24 clearly specify that the claimed process heater is a "flameless distributed combustion" process heater. Support for "flameless combustion" and "distributed combustion" is found on page 4, lines 12-14 and page 5, lines 5, 16 and 26.

no def. of distributed combustion

Turning now to the specific language in the claims of concern to the Examiner, the recitation in claim 1 "with each nozzle along the flowpath between the inlet and outlet", which the Examiner found unclear, has been deleted.

Claim 1 has been amended to recite the preheater is in "fluid" communication with the oxidation chamber. Thus, the kind of communication is now specified. Support for this amendment is found on page 8, lines 4-9 and Fig. 1 of the present application, in

which preheater 7 is shown to heat an oxidant stream (a fluid) which flows into (and thus is in communication with) oxidation chamber 1.

The above amendments to claim 1 are believed to address the Examiner's concerns about certain terms in claim 1 having insufficient antecedent basis.

change to temp.

The term "the temperature" now clearly refers to the temperature of the "oxidant " which term has its antecedent basis on line 2 of twice amended claim1.

The term "the combined oxidant and fuel" has been amended to recite "oxidant and fuel when mixed in the oxidation chamber" on line 12 and "mixture of oxidant and fuel" on line 13 of twice amended claim 1. Antecedent basis for the term for the term "mixture of fuel and oxidant" is found on line 8 of twice amended claim1, wherein it is stated "that no flame results the fuel is mixed with the oxidant flowing through the flow path in the oxidation chamber".

The term "the fuel nozzle closest to (...)", for which the Examiner believed there was insufficient antecedent basis, has been deleted.

delete the (depends on pressure etc.)

The term "the autoignition temperature" clearly refers to the autoignition temperature of the "mixture of oxidant and fuel", the antecedent basis for which is discussed above.

The term "the heat" now clearly refers to the heat transferred from the oxidation chamber to the process chamber, as set forth on lines 16-18 of twice amended claim 1.

The term "the temperature" now clearly refers to the temperature "of the mixture of oxidant and fuel within the oxidation chamber", the antecedent basis for which is discussed above.

The term "mixture" has been amended to read "mixture of oxidant and fuel", the antecedent basis for which is discussed above.

The term "vicinity", for which the Examiner believed there was insufficient antecedent basis, has been deleted.

The term "the combined mixture" has been amended to recite "said mixture of oxidant and fuel", the antecedent basis for which is discussed above.

The term "that fuel nozzle", for which the Examiner believed there was insufficient basis, has been deleted.

The above amendments to claim 2 to are believed to address the Examiner's concerns about insufficient antecedent basis for terms "the coke inhibitor system" and "the fuel supply conduit". Twice amended claim 2 now recites "the coke inhibitor <u>injection</u> system" the antecedent basis for which is "a coke inhibitor injection system" on lines 1-2 of said claim. The term "the fuel supply conduit" has been amended to read "the fuel conduit", the antecedent basis for which "a fuel conduit" on line 4 of twice amended claim 1.

The phrase "can be", formerly in claim 2, which the Examiner believed rendered the claim indefinite, has been deleted. Twice amended claim 2 now specifies that "an amount of coke inhibitor <u>is</u> supplied effective to inhibit coke formation".

Claims 3-4 have been amended to recite "the oxidation chamber", instead of "the oxidation reaction chamber". Antecedent basis for "the oxidation chamber" is "an oxidation chamber" on line 2 of twice amended claim 1, from which claims 3-4 depend.

Claim 5 has been amended to clarify that "the production of olefins" results from the "thermal cracking of hydrocarbons" when "the process chamber" of the claimed

process heater is "a pyrolysis reaction chamber". The antecedent basis for "the process chamber" is "a process chamber" on line 14 of twice amended claim 1. Support for this amendment is found on page 14, lines 12-14 of the present specification. The phrase "the production of olefins" as used in this claim is not believed to require a separate antecedent basis.

? why not

Claim 6 has been amended to delete the language the Examiner found unclear. Amended claim 6 now specifies the process chamber contains catalyst and is used for steam methane reforming. Support for the amendments is found on page 13, lines 21-25 of the present specification.

Claims 13-15 no longer contains the term "the process" which the Examiner believed lacked antecedent basis. Instead these claims recite the specific uses of the process chamber, the antecedent basis for which is "a process chamber" on line 14 of twice amended claim 1. Support for the amendments is found on page 4, line 26 to page 5, line 15 and page 14, lines 24-25 of the present specification .

The amendments to claims 14-15 are believe to clarify that the process chamber, which is one of the three basic elements of the claimed process heater, is used for the vacuum flash distillation of a feed or is used as a hydrocarbon distillation column reboiler. Support for these amendments is found on page 14 of the specification, lines 24-25.

New claim 16 claims the embodiment of the present invention in which heat is continuously added to the reaction in the process chamber, resulting in a single stage

reaction at a controlled temperature profile. Support for this amendment is found on page 5, lines 11-13 of the present specification.

New claim 17 claims the embodiment of the present invention where the oxidant is preheated with effluent from the process chamber. Support for this amendment is found on page 8, lines 6-9 of the present specification.

8. and 9. In these paragraphs the Examiner has rejected claims 1-7 and 13-15 under 35 U.S.C. 102(b) as being anticipated by Ruhl (EP 0 450 872). This rejection is respectfully traversed.

While, as pointed out by the Examiner, the endothermic reaction apparatus disclosed in Ruhl comprises many of the same elements as the process heater of the present invention, Ruhl is deficient as an anticipatory reference in at least two key respects. Ruhl does not disclose <u>flameless</u> combustion, nor does it disclose <u>distributed</u> combustion, both of which are at the heart of applicant's invention. Nowhere in Ruhl is there an express teaching of flameless combustion or how flameless combustion can be achieved. It is true that Ruhl does disclose on page 5, lines 54-55, in connection with the apparatus of Fig.4, that "the fuel will mix with the air fed via inlet 40 to manifold 42 and into the burner zone 68 and autoignite to heat the reactor". However, heating to a temperature above the autoignition temperature of the fuel-oxidant mixture does not necessarily result in flameless combustion. Note in the apparatus shown in Fig. 5 of Ruhl, that the fuel is said to autoignite in <u>flame</u> zone 90 to produce the heat for conducting the endothermic reaction (Ruhl, page 6, lines 4-5). Therefore, it is submitted that Ruhl's teaching of autoignition does not anticipate claim 1 of the present application, especially as now amended to delete the "capable of" language and to specifically recite that the

how about 4. Fig 5 never was flame but burner in other embodiments was flame!

no proof that they are not in Ruhl

fuel nozzles are "spaced so that fuel is added to the oxidation chamber at a rate <u>that no flame results</u> when fuel is mixed with the oxidant". Support for this amendment is found on page 6, lines 25-27 of the present specification. Since Applicant's claim 1 now expressly requires flameless combustion, i.e., "that no flame results", the present claim clearly is not anticipated by Ruhl for this reason alone, i.e., Ruhl only teaches "autoignition", not flameless combustion or how flameless combustion can be achieved. As explained on page 6, lines 1-3 of the present application, in order to achieve flameless combustion it is important that the fuel nozzles and oxidation chamber be designed such that fuel and air velocities are high enough to blow-off any stabilized flame. This concept is totally lacking in Ruhl, who does not appear to be at all concerned about blowing-off stabilized flames, but in fact utilizes a stabilized flame in most, if not all, of the embodiments shown.

[illegible] appear any velocity can be used. (intended use)

It is noted that newly added claims 18-24 all specifically recite that the claimed process heater is a <u>flameless</u> distributed combustion process heater and that the fuel nozzles are spaced so "that no flame results". Therefore, the new claims are likewise patentable over Ruhl for this reason as well as those reasons discussed below.

no def. of distributed comb. in spec. (along entire length)

In addition to no express teaching of "flameless combustion ", Ruhl also does not teach what Applicant refers to as "distributed" combustion. In order to achieve "distributed" combustion it is important that the plurality of fuel nozzles in the fuel conduit extend along the length of the oxidation chamber (see page 7, lines 16-22 of the present application). Since the oxidation chamber is in a heat exchange relationship with the process chamber, the distributed combustion in the oxidation chamber results in the

provision of the desired temperature distribution within the process chamber, which in turn results in improved conversions, product yields, byproduct reduction, etc.

While Ruhl states on page 5, lines 51-52 that the feed gas tube has perforations or holes 64 at spaced intervals along its length, when one refers to Fig. 4 it can be seen that the perforations 64 are spaced <u>only in burner zone 68</u>. There are no perforations in the upper portion of the fuel tube. This uneven distribution of perforations in the feed gas tube will result in an uneven temperature distribution in combustor tube 30, with the temperature in the lower "burner zone" of the combustion tube being much greater than the temperature in the upper portion of combustion tube. This conclusion is supported by the statement in Ruhl on page 5, lines 55-56, that plug 66, which is at the upper end of fuel tube 60, "need not resist very hot temperatures and thus could be made of graphite or heat resistant organic cement". Based on the location of the perforations in fuel tube 60 in Fig. 4 and the foregoing statement about plug 66, it is clear that Ruhl does not disclose "distributed' combustion, nor would the apparatus in Ruhl be able to achieve the same desired temperature profiles in a process chamber that are achievable by Applicant's in process heater. Therefore, Ruhl does not anticipate claims 1-7 and 13-15, especially as amended to require "a plurality of fuel nozzles along the length of the oxidation chamber" and that "a controllable heat flux is provided to the process chamber". Support for these amendments is found in the present specification on page 7, lines 16-17 and page 4, lines 12-14 , respectively.

Since newly added claims 18-24 specifically require flameless distributed combustion and that the plurality of nozzles be "distributed along the length of said

oxidation chamber", these claims likewise are believed to be patentable over Ruhl for this reason, as well as the other reasons discussed above.

For all of the foregoing reasons, and in view of the amendments, it is submitted that all of the claims now in the application are clearly patentable over Ruhl. Hence, the rejection of these claims on the basis of Ruhl should be withdrawn, which action is respectfully requested.

10. and 11. In these paragraphs the Examiner has rejected claims 1-7 and 13-15 under U.S.C. 103(a) as being unpatentable over Ruhl (EP 0 450 872) in view of Mikus (USP 5,255,742). This rejection is also respectfully traversed.

As discussed above, while Ruhl discloses an endothermic reaction apparatus comprising many of the same elements as the process heater apparatus of the present invention, Ruhl is deficient as a reference in at least two key respects. Ruhl does not disclose <u>flameless</u> combustion (or how one would achieve flameless combustion), nor does Ruhl disclose <u>distributed</u> combustion along the length of the oxidation chamber, both of which are important to applicant's invention. Claim 1, as twice amended, (and all the claims that depend there from) contain the limitations that "the fuel nozzles are spaced so that fuel is added to the oxidation chamber so that no flame results when the fuel is mixed with the oxidant" and that the fuel conduit contains "a plurality of fuel nozzles along the length of the oxidation chamber" and that the "a controllable heat flux is provided to the process chamber". None of these features is taught or suggested by Ruhl.

The Examiner's reliance on Mikus to overcome these deficiencies is believed misplaced. Contrary to the statement made by the Examiner, Mikus does not teach "a

any heater teaching

process heater", at least not as this term is used in the present application to describe a process heater apparatus including a process chamber as an essential element. The heater in Mikus (more properly referred to as a fuel gas combustor, heat injector, or well heater) is used for the injection of heat into a subterranean formation of low permeability, such as diatomites and oil shale to enhance the recovery of oil. (Col. 1, lines 9-10, col. 3, line 3, col.8, line 37 and col.9, line 29). The fuel gas combustor/heat injector/well heater disclosed in Mikus has absolutely nothing to do with providing heat to an endothermic chemical reaction, nor does it contain a process chamber, a reaction vessel or anything similar which would provide a basis combining this reference with Ruhl.

As stated in the accompanying affidavit by Dr. Thomas Mikus, he invented the flameless combustion heat injector disclosed in the Mikus reference to provide heat to a well drilled through rocky materials. The heat injector was developed to replace electric line source heaters. Because rocky materials are very poor conductors of heat, the heat injector in the Mikus reference was seen as a uniform, low flux, linear heat source, that typically provided only about 375 Watts per foot of length along the well (See col. 10, lines 6-13 of Mikus).

In contrast, as stated in the Mikus affidavit, endothermic chemical processes require significantly greater amounts of heat, since the flowing process streams can carry the heat away from the heat source much faster than the rocky materials in a subterranean formation. According to the Mikus affidavit, chemical process streams typically absorb an order of magnitude higher heat flux than produced by a heater of the same diameter as the well in the Mikus reference. For example, to provide heat at a constant temperature to a process for the production of ethylene by the thermal cracking of hydrocarbons could

many variables

require a profile of heat flux varying with distance from 3,500 to 7000 Watts per foot. This compares to 375 Watts per foot produced by the heater employed in the examples in the Mikus reference.

As stated Dr. Mikus in his affidavit, for the foregoing reason, the applicability of the flameless distributed combustion heat injectors to chemical process applications was unforeseen and not predictable. It was more than a decade after the Mikus patent issued, that Dr. Mikus and his co-inventors built a new test rig to test a process heater design based on flameless distributed combustion. Until these tests were conducted Dr. Mikus and his co-inventors had no way of knowing whether the FDC concept would work in heater for a chemical process. As stated in the affidavit, it was very surprising to Dr. Mikus and unexpected that the FDC process heater worked as well as it did.

when looking for a heater in you look for dao heaters when looking for reactors -Jcv

The inappropriateness of combining Mikus with Ruhl is further evident from the classifications of each of the references. The Mikus reference is classified in International Classes/Subclasses E21B 36/02 dealing with "Earth drilling, e.g., deep drilling …heating, cooling or insulating arrangements for boreholes or wells, e.g., for use in permafrost areas, using burners. Ruhl, on the other hand, is classified in International Classes/subclasses B01J 8/06, B01J 8/04, C01B 3/38, Chemical or physical processes, e.g., catalysis, colloid chemistry, their relevant apparatus, …in tube reactors; the solid particles being arranged in tubes, the fluid passing through two or more beds, inorganic chemistry, hydrogen; gaseous mixtures containing hydrogen, separation of hydrogen from mixtures containing it, …using catalysts.

Since Mikus is in a totally different art area (earth drilling, heating, cooling insulating arrangements for boreholes) than Ruhl (chemical or physical processes

involving tube reactors and catalysts), applicant submits there is no reasonable basis for combining the teachings of these references, other than hindsight reconstruction using Applicant's own disclosure which, of course, is not permitted. One attempting to improve means for providing heat to an endothermic chemical reaction would not look to the earth drilling/oil recovery art for a solution.

Even if one skilled in the art working on improving the efficiency of an endothermic chemical reaction somehow stumbled across Mikus in a nonanalogous art area, as stated in the Mikus affidavit, it still would not be predictable that flameless distributed combustion used for heat injection underground, could be effectively employed as a process heater for an endothermic chemical reaction because of the much greater heat flux required for such reactions. At best it might be "obvious to try" the Mikus heat injector in this application. However, "obvious to try" is not proper test for obviousness. In re Antonie, 559 F.2d 618, 195 U.S.P.Q. 6 (CCPA, 1977)

It was Applicant who discovered the unexpected benefits in improved conversions, selectivities and/or yields, etc., when a process chamber is integrated with and oxidation chamber designed for flameless distributed combustion to produce a controllable heat flux in the process chamber. This discovery is not anticipated by, or obvious from, Ruhl either alone or in combination with Mikus. Thus, Applicant is entitled to patent protection for this very significant invention.

Accordingly, it is respectfully requested, in light of the foregoing remarks and the amendments, that all of the claims remaining in the case be allowed, and that the application be passed promptly to issuance.

Respectfully submitted,

Rashmi K. Shah et al

By: Y. Grace Tsang

Their Attorney, Y. Grace Tsang and
Leonard P. Miller
Reg. Nos. 31,672 and 26,004
(713) 241-0956

P. O. Box 2463
Houston, Texas 7725-2463

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TH-1042

Marked up Paragraphs Showing Amendments to Specification

First paragraph on page 10 of the specification:

The carbon dioxide and the carbon monoxide remain in equilibrium at elevated temperatures according to the shift gas reaction:

$$CO + H_2O\ [+C] \Leftrightarrow CO_2 + H_2 \qquad (5)$$

Second full paragraph on page 11 of the specification:

Referring now to FIG. 4, the process chamber is within the combustion chamber conduits which define combustion chambers 1, and the conduits defining the combustion chambers [6] <u>1</u> are within a larger conduit, the fuel flowing inside of the larger conduit and outside of the conduits that define the oxidation chambers. Fuel nozzles 6 are located in the conduits separating the fuel from the oxidation chambers, with the fuel flowing through the nozzles into the oxidation [nozzles] <u>chambers</u>. The advantage of this configuration is that only one large conduit is required for fuel flow.

Paragraph bridging pages 11 and 12:

Referring now to FIG. 7, an arrangement similar to FIG. 5 is shown with an additional feature that the combustion chamber flow is split, with the inlet to the oxidation chamber [2] <u>1</u> being near the center of the length of the oxidation chamber [8] <u>1</u>. Flow from the inlet splits into a flow going in each direction. This split oxidation chamber permits longer process chamber flowpath for the distance of the combustion chamber flowpath, and reduces the flow in the oxidation chamber by half. Thus, the pressure drop is reduced by a factor of about eight for similar dimensions for the

combustion flowpath. This can be beneficial because of the importance of compression costs in the economics of the process. This alternative may be desirable where it is desirable to have a relatively long straight flowpath for the process. As another alternative, the fuel conduit may be outside of the oxidation chamber as in FIG. 6.

First full paragraph on page 7:

A process chamber 8 is in heat exchange relationship to the oxidation reaction chamber 1. A process stream enters the process chamber at the inlet 11 and exits at an outlet 12. A quench heat exchanger 10 is shown to cool the process stream exiting the process chamber. The quenched (cooled) process stream exits the quench heat exchanger at outlet 15. A stream to be heated by the quench heat exchanger enters at quench inlet 14 and exits through quench outlet 13. The stream to be heated by the quench heat exchanger may be, for example, a process inlet stream, a boiler feed water stream that is heated and/or vaporized. In some processes, such as pyrolysis of hydrocarbons to produce olefins, rapid quench is desirable to reduce reactions to byproducts.

Marked Up Copy of Amended Claims

1. (Twice amended) A process heater comprising:

an oxidation chamber, the oxidation chamber having an inlet for an oxidant, an outlet for combustion products, and a flow path between the inlet and the outlet;

a fuel conduit [capable of] for transporting a fuel [mixture to] to the oxidation chamber, the fuel conduit containing a plurality of fuel nozzles [within] along the length of the oxidation chamber, each nozzle providing fluid communication from within the fuel conduit to the oxidation chamber, [with each nozzle along the flowpath between the inlet and the outlet] the fuel nozzles being spaced so that fuel is added to the oxidation chamber at a rate that no flame results when the fuel is mixed with the oxidant flowing through the flow path in the oxidation chamber;

a preheater in fluid communication with the oxidation chamber inlet, the preheater capable of increasing the temperature of the oxidant to a temperature resulting in the [combined] oxidant and fuel when mixed in the oxidation chamber [from the fuel nozzle closest to the oxidation chamber inlet] being hotter than the autoignition temperature of [the combined] said mixture of oxidant and fuel [from the fuel nozzle closest to the oxidation chamber inlet]; and

a process chamber in a heat exchange relationship [to] with the oxidation chamber [wherein] whereby a controllable heat flux is provided to the process chamber, and the heat transferred from the oxidation chamber to the process chamber does not cause the temperature of the mixture of oxidant and fuel within the oxidation chamber [in the vicinity of each fuel nozzle] to decrease below the autoignition temperature of [the

combined] said mixture of oxidant and fuel in the oxidation chamber [in the vicinity of that fuel nozzle and the fuel noxxles are capable of distributing fuel into the oxidation chamber without forming a flame].

2. (Twice amended) The process heater of claim 1 further comprising a coke inhibitor injection system, the coke inhibitor injection system being in fluid communication with the fuel [supply] conduit wherein an amount of coke inhibitor is supplied [can be] effective to inhibit coke formation at fuel conduit operating temperatures.

3. (Amended) The process heater of claim 1 wherein the fuel conduit is a tubular conduit essentially centrally located within the oxidation [reaction] chamber.

4. (Amended) The process heater of claim 3 wherein the oxidation [reaction] chamber is essentially centrally located within the process chamber.

5. (Amended) The process heater of claim 1 wherein the process chamber is a pyrolysis reaction chamber for the thermal cracking of hydrocarbons in the production of olefins.

6. (Amended) The process heater of claim 1 wherein the process chamber [is effective as a] contains a catalyst and is used for steam methane reforming [reaction chamber].

7. (Amended) The process heater of claim1 wherein the process [heater] chamber contains catalyst and is [a] used for the production of styrene by the dehydrogenation of ethylbenzene [dehydrogenation heater].

13. (Amended) The process heater of claim1 wherein the process [comprises] chamber is used for an endothermic chemical reaction.

14. (Amended) The process heater of claim1 wherein the process chamber is used for the [a] vacuum flash distillation of a feed [heater].

15. (Amended) The process heater of claim 1 wherein the process chamber is a hydrocarbon distillation column reboiler.